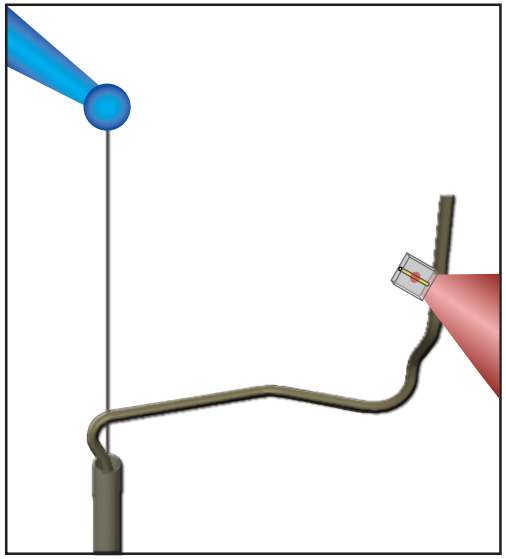
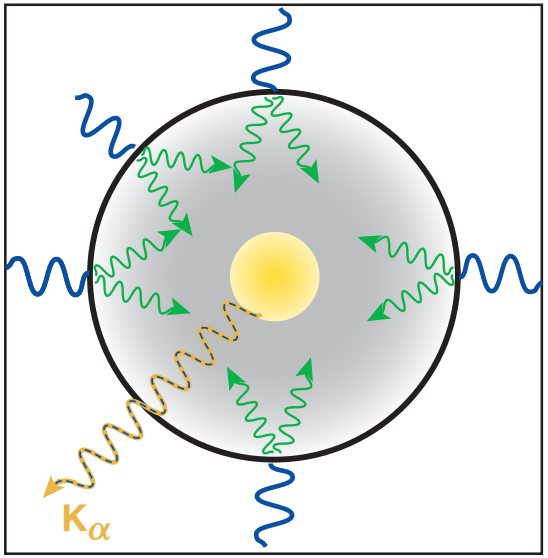
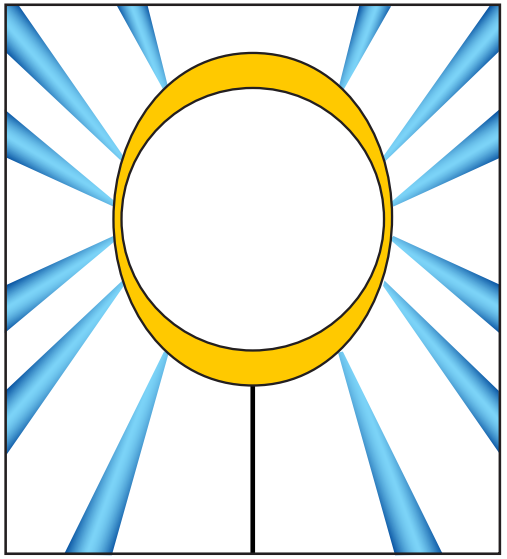
Overview of the Requirements and Construction of Targets for Experiments on OMEGA and OMEGA EP







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20th Target Fabrication Meeting
Santa Fe, NM
20–24 May 2012

Summary

Complex targets have been developed for three experimental campaigns

UR LLE

- Cryogenic Compton radiography campaign
  - 60-beam OMEGA laser implodes a cryogenic capsule with 100-μm-thick DT ice

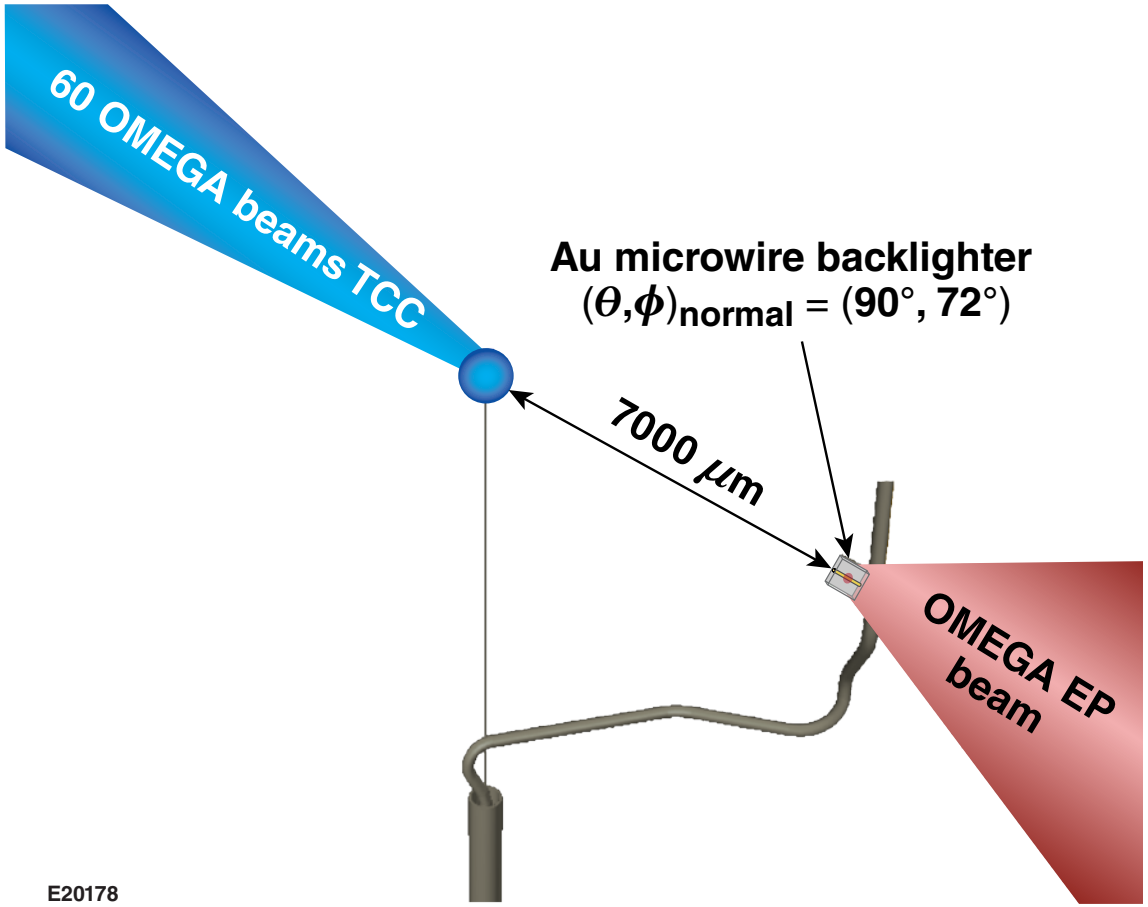
    Issue: tolerances on backlighter position relative to the capsule source
- Two-plamon-decay experiments
  - a 200-μm-diam molybdenum (Mo)-coated capsule co-centered with a GDP capsule

    Issue: centering the two capsules to ±50 μm (radius) and reducing the seam size
- Polar-drive shimmed (PDS) target
  - the PDS capsule has a constant inner radius and a varying wall thickness

    Issue: wall-thickness variation and mounting strategy

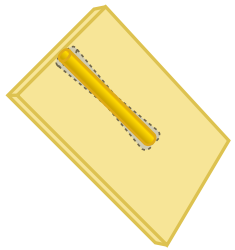
Compton radiography cryogenic target assembly requires strict tolerances

- The capsule implosion is backlit with x rays (60 to 200 keV) to image the core

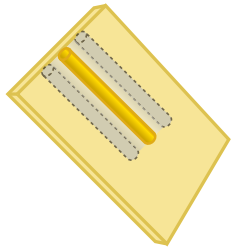


E20178

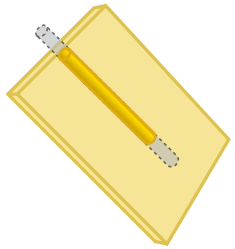
Point-projection gold microwire positioning tolerances



±2° (pixel resolution)

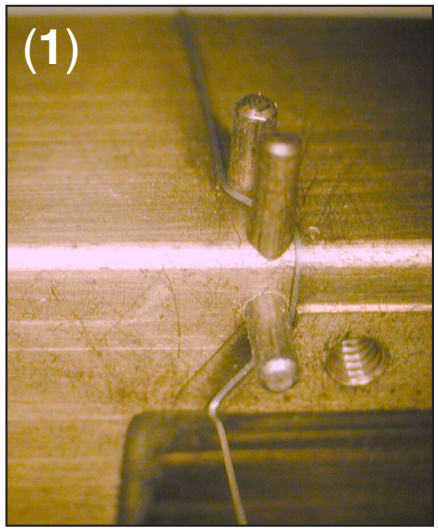


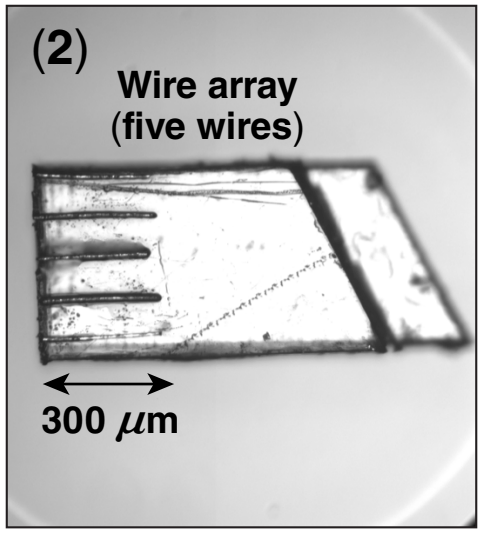
±25 μm (OMEGA EP pointing, image displacement)

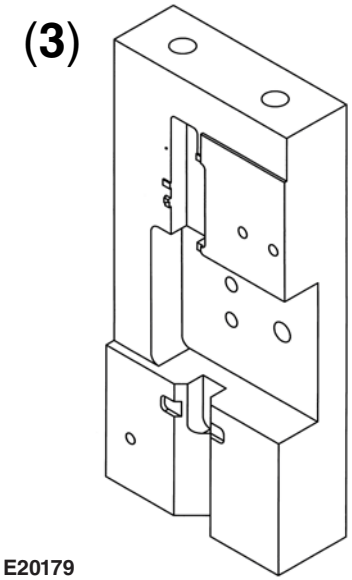


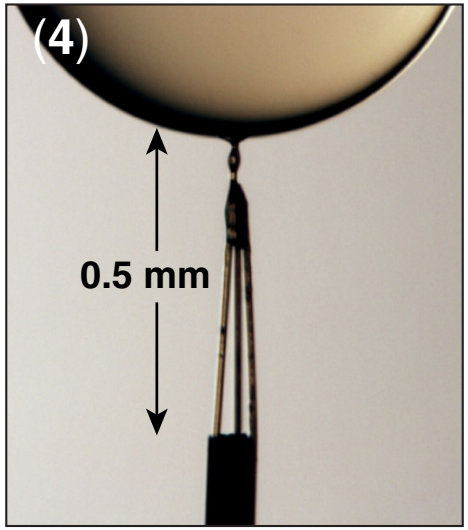
±50 μm (OMEGA EP pointing)

Constructing the target assembly is a multi-step process







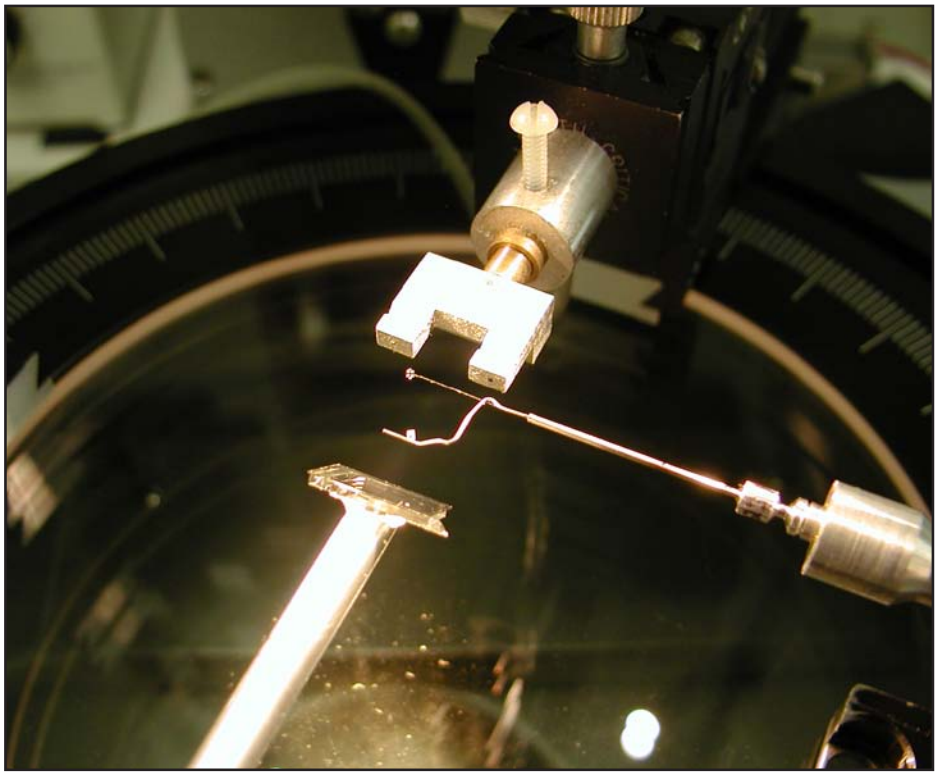


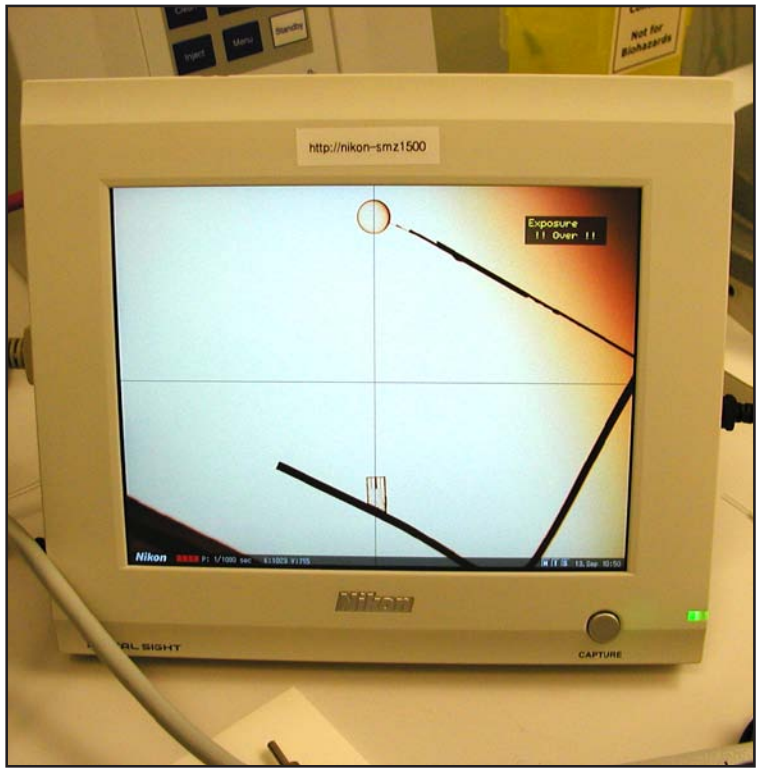
E20179

1. 250-μm-diam Be wire is formed at 400°C in a geometry avoiding beam interferences
2. 10-μm-diam gold wire array is assembled and characterized
3. Be wire, backlighter subassembly, and target holder are assembled on a fixture
4. 14-μm-diam PBO fibers (Zylon) are constructed in a tripod arrangement

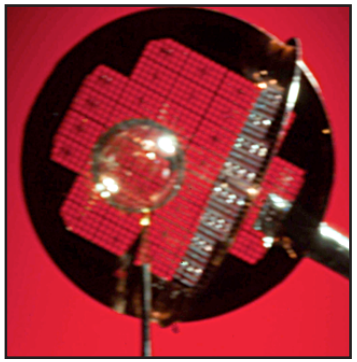
The capsule is positioned and joined to the target mount

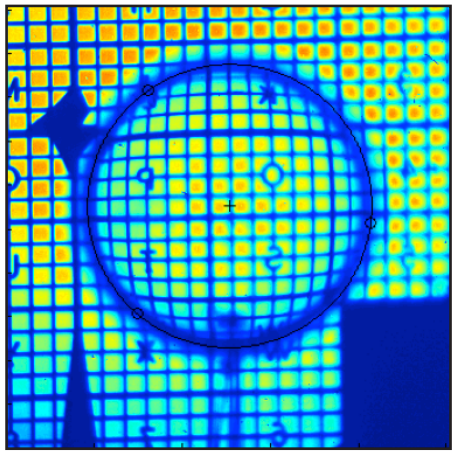
- The completed assembly is measured using the Nikon software package



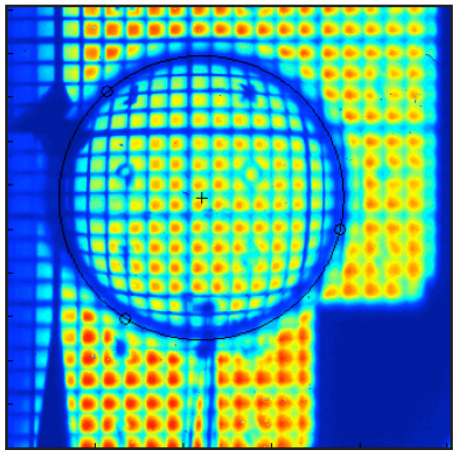


Cooling the Compton radiography target to 15 K induced dimensional changes (<100 μm) that are manageable



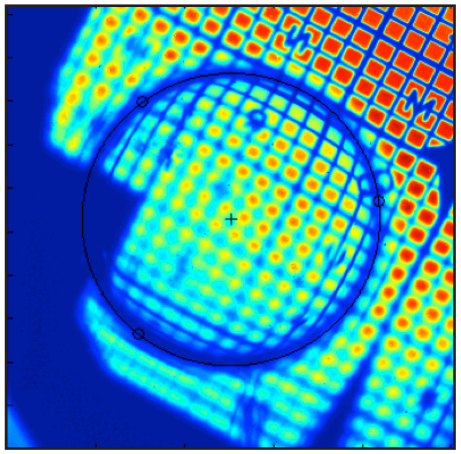


x view 300 K

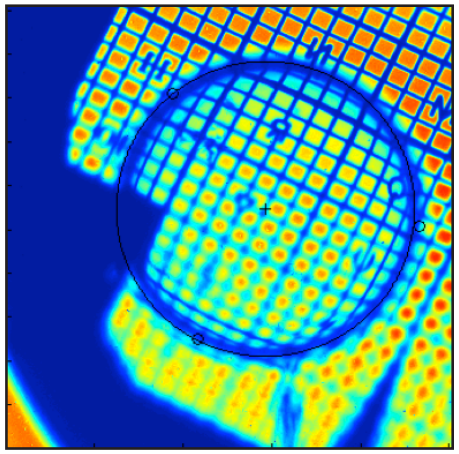


x view 15 K

Moved 30 μm



y view 300 K



y view 15 K

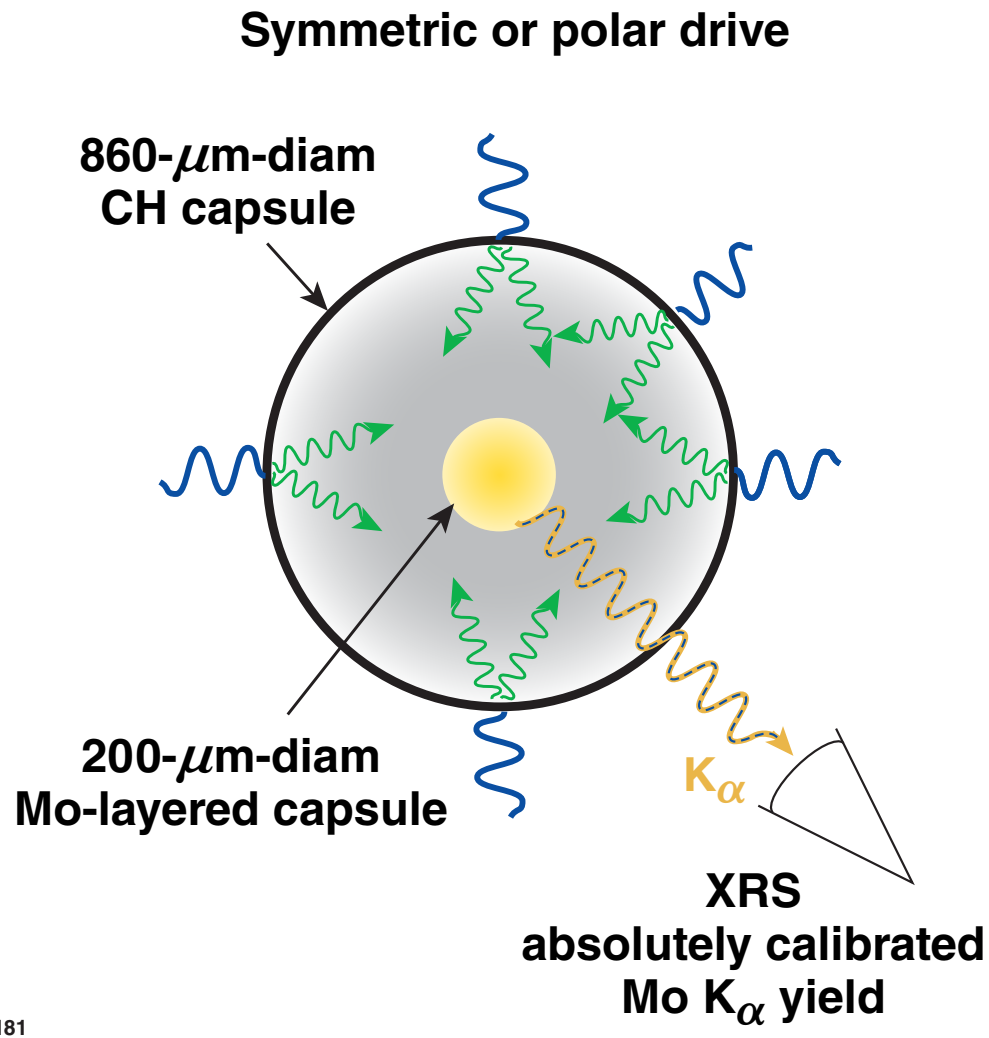
Moved 70 μm

This suggests a 200-μm-diam core can be imaged.

E20180a

Integrated two-plasmon-decay experiments on OMEGA will address electron coupling for direct-drive implosions

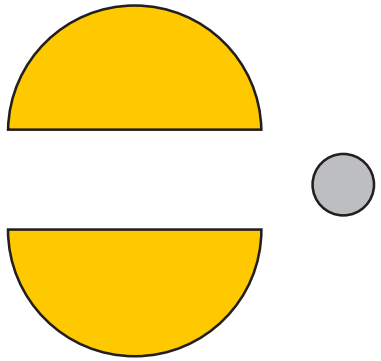
UR LLE



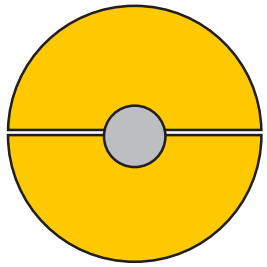
- "Preheat" is from laser/ plasma interaction-generated electrons (50 to 150 keV) that can reduce compressibility
- The amount of preheat is measured by the K_α yield of a molybdenum capsule inside a 20-μm-thick GDP capsule
- Requirements
  - ≥30 μm molybdenum on inner capsule
  - seam must be gap-free
  - concentricity to ±50-μm radius

E20181

Using a halfraum assembly approach, a molybdenum-coated capsule* is centered inside two hemispheres



1. Machine-matched sets of hemispheres (same wall thickness, measurement error ±0.3 μm; outer diameter, ±5 μm); to be completed at GA



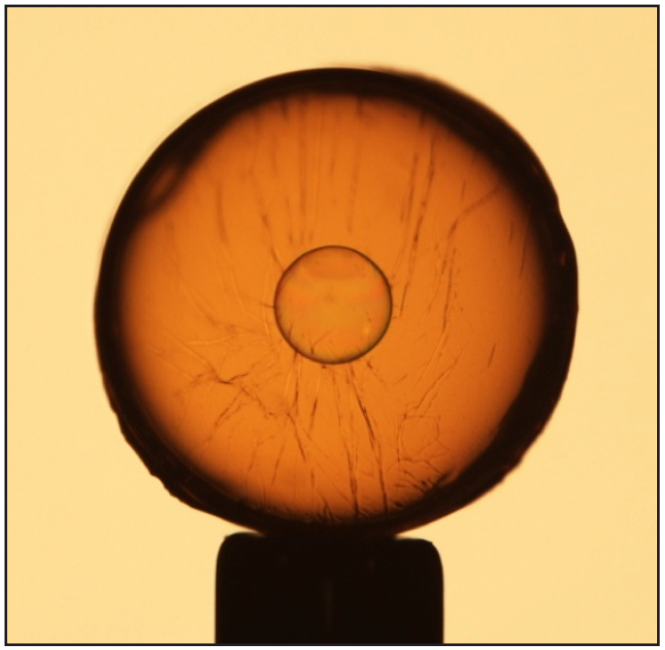
2. Insert molybdenum-coated capsule using (a) formvar or (b) spider silk; add viscous glue to the seam to prevent laser light going into the center; to be completed at LLE

*J. Jaquez, General Atomics.

A prototype target was made using formvar to center the inner capsule

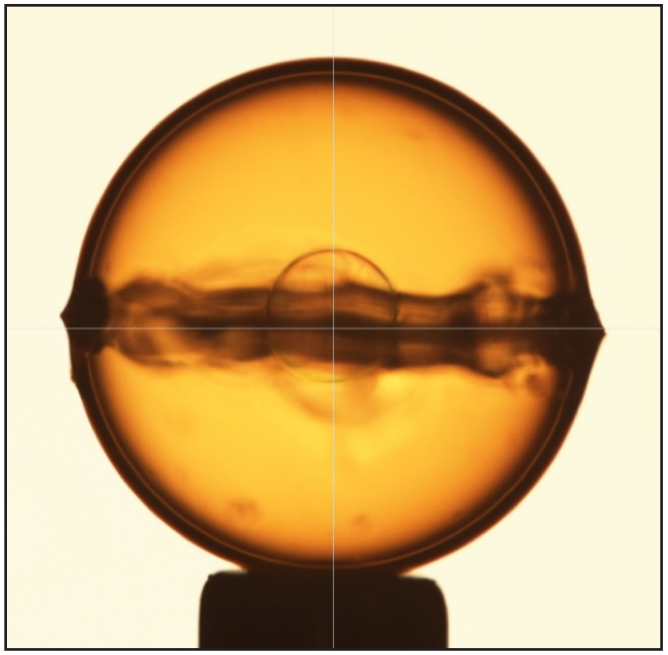
UR LLE

Top view



218-μm-diam glass capsule co-centered to 8 μm of the GDP capsule outer diameter

Side view

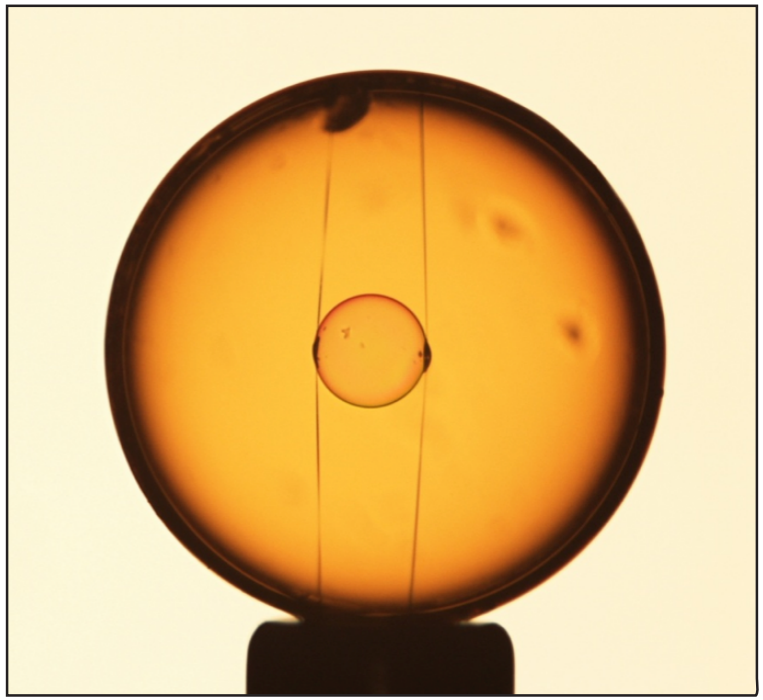


Seam is in view, glass capsule is centered to 9 μm of the outer diameter; seam width ~90 μm

Mounting the inner sphere using spider silk is another viable approach to achieve ±50-μm concentricity requirement

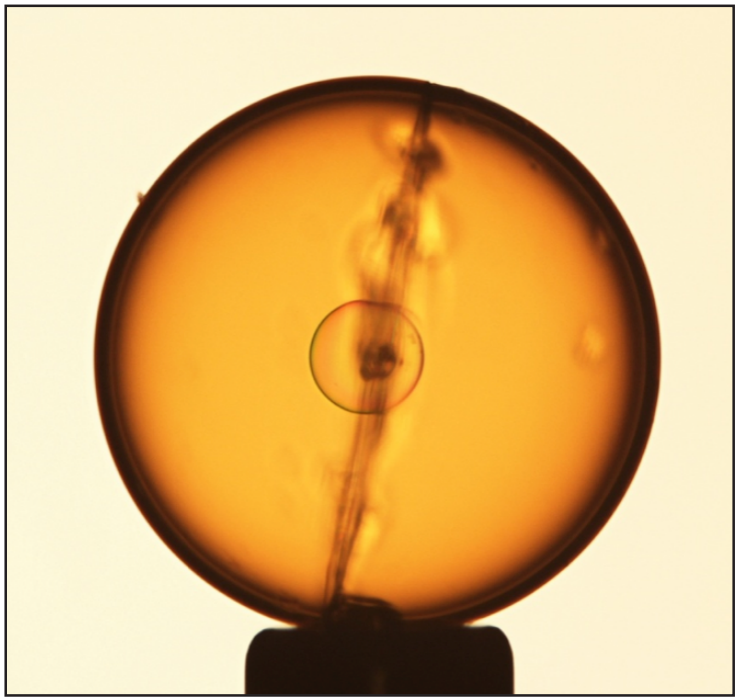
UR LLE

Top view



Glass capsule is within 20 μm of center of the GDP capsule

Side view



Glass capsule is within 14 μm of center of the GDP capsule

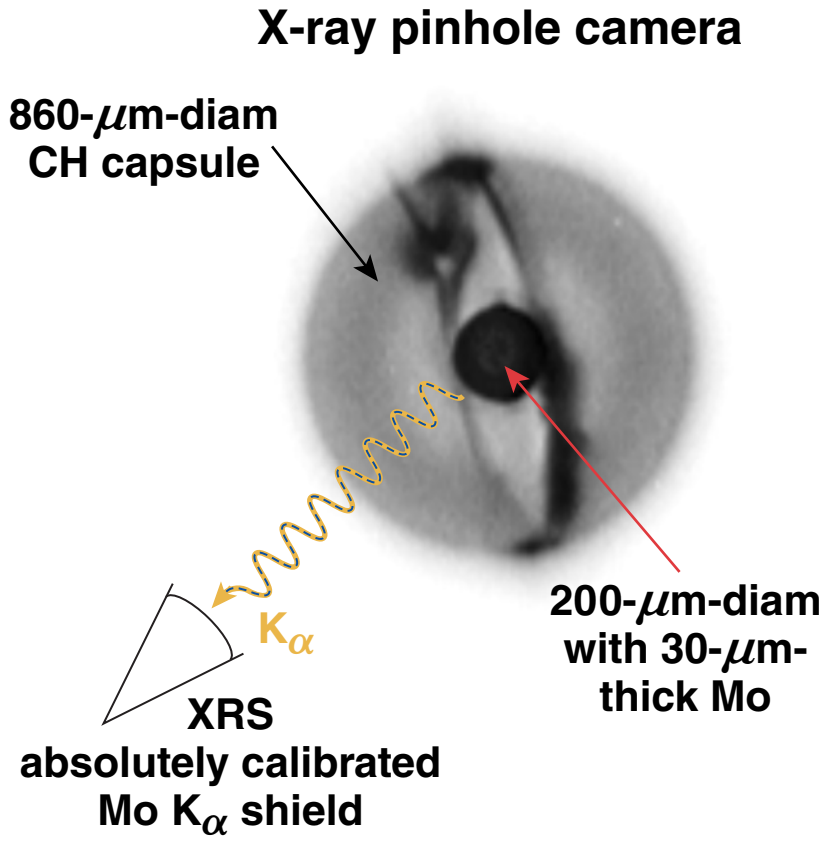
Challenges:
- reduction of adhesive at seam
- handling molybdenum coating on 140-μm-diam glass

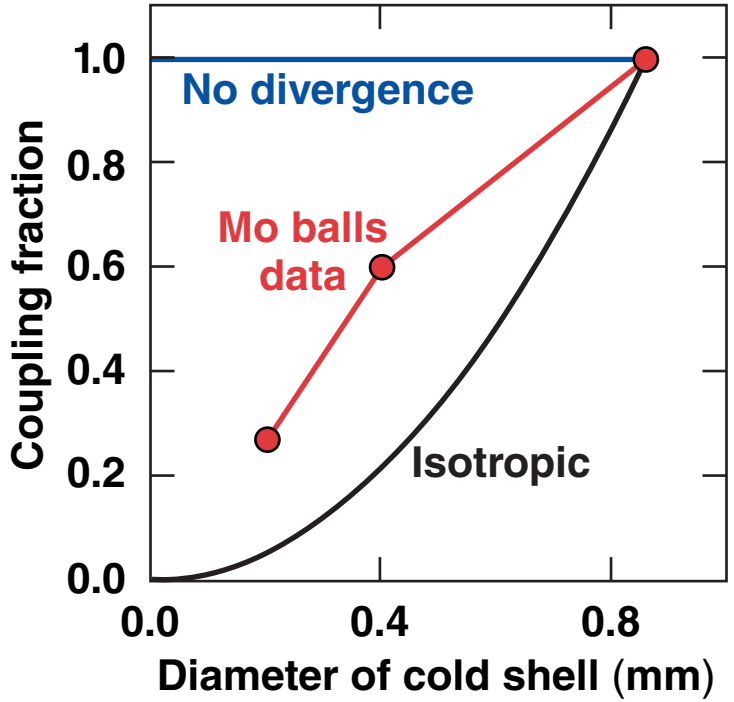
E20189

Results

The fraction of hot electrons reaching the cold shell is measured using Mo-coated capsules

UR LLE

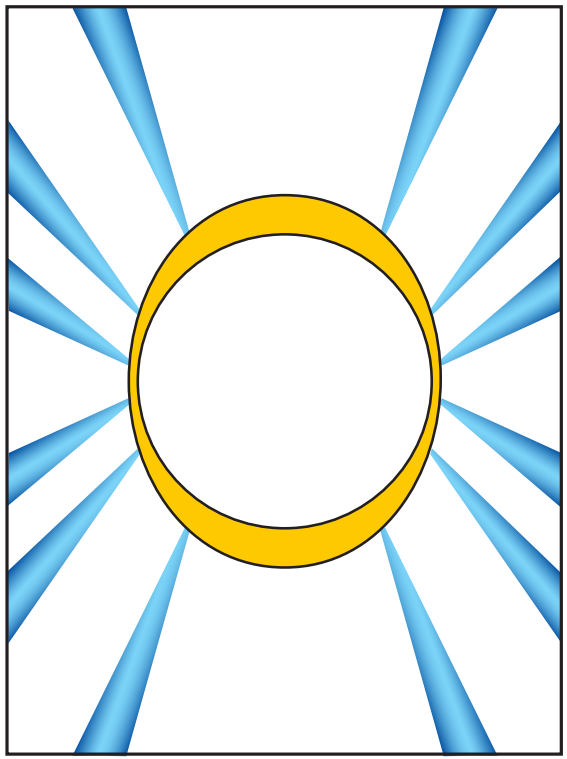




These experiments currently provide an upper bound on the fraction of hot electrons that reach the cold shell (preheat).

E21184

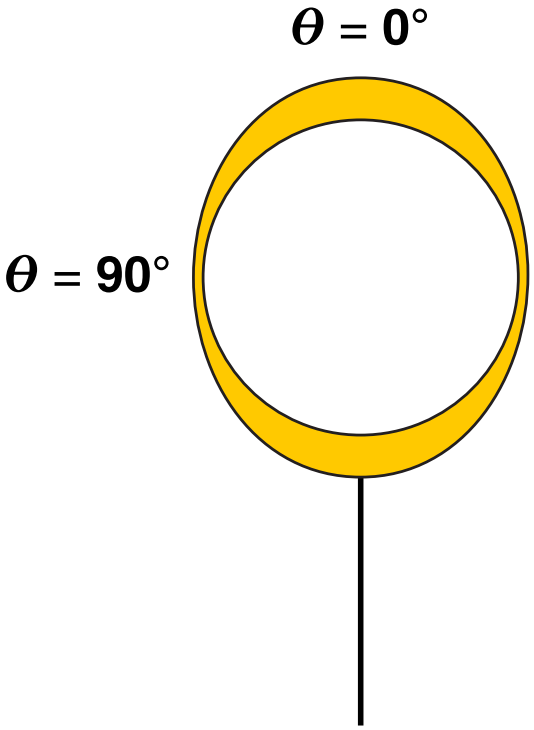
Polar-drive shimmed (PDS) targets have been fielded on OMEGA

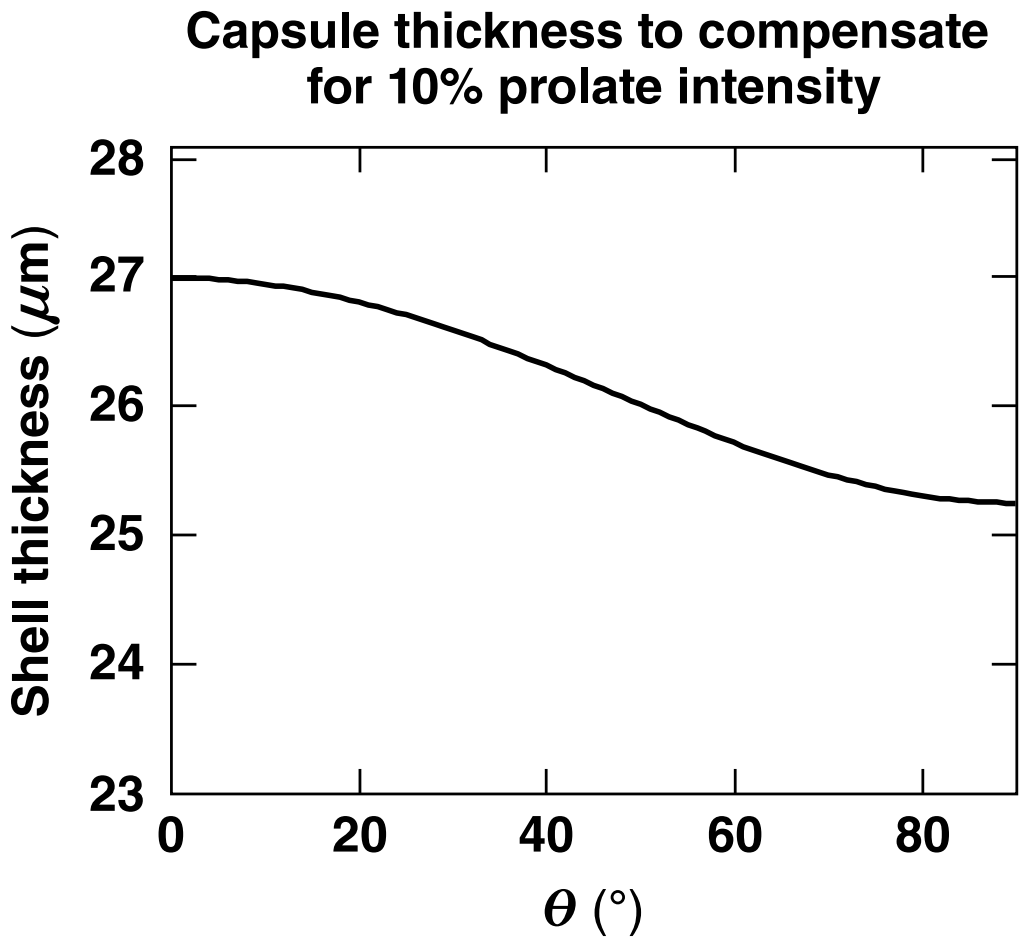


- 40-beam OMEGA shots
- Asymmetric intensity
- Displaced pointing

A shimmed capsule will implode uniformly, compensating for the asymmetric illumination.

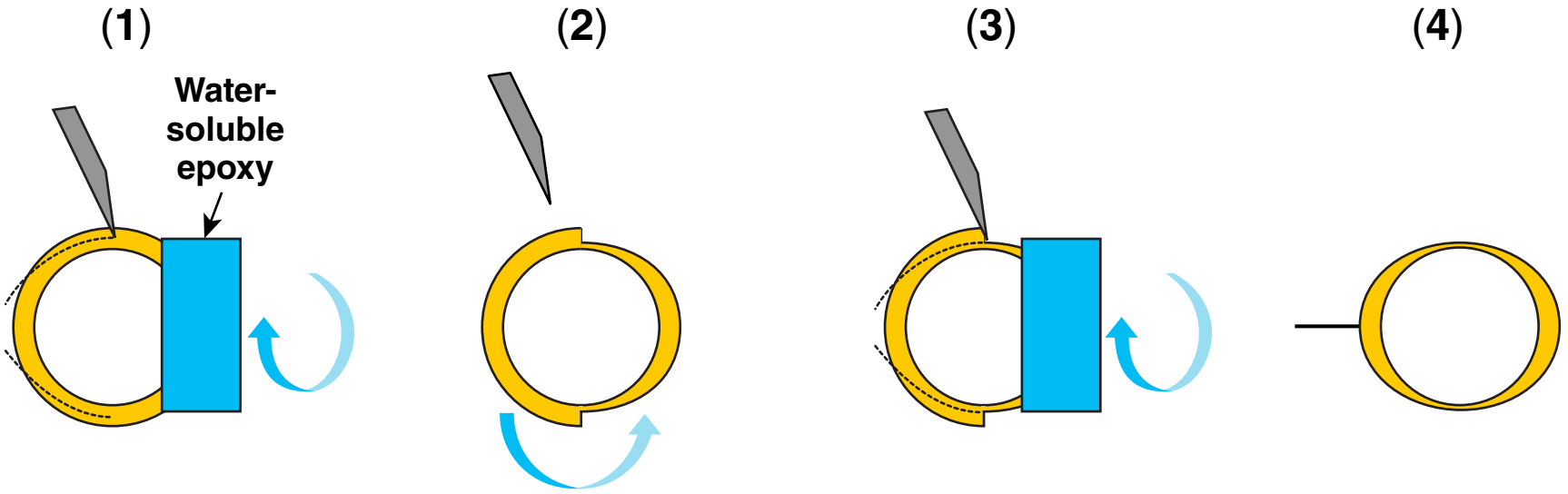
A polar-drive shimmed target uses a capsule with variable wall thickness





E20185

Polar-drive shimmed targets are machining intensive



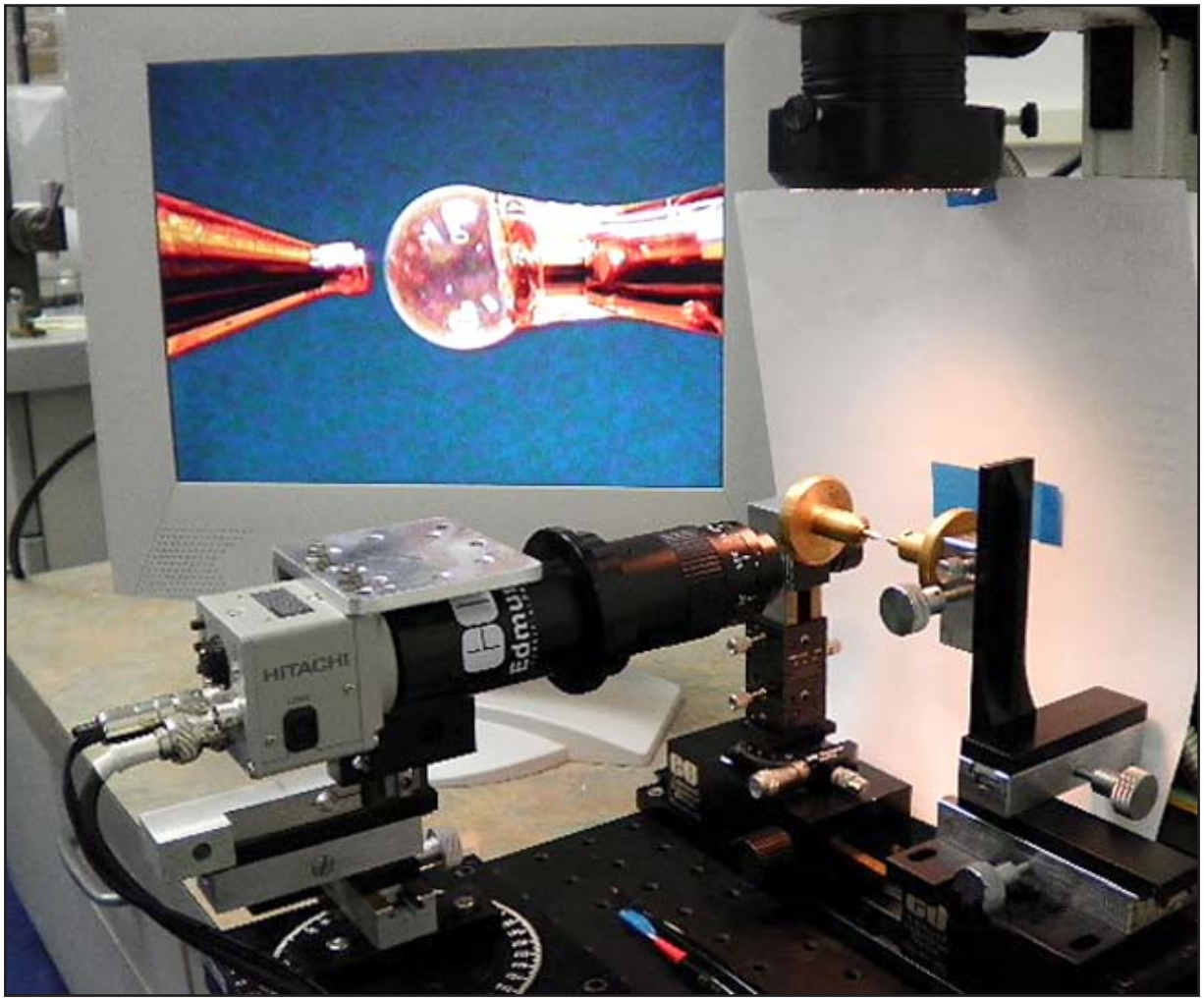
Turn pattern

Dissolve adhesive, rotate 180°

Turn pattern on other side

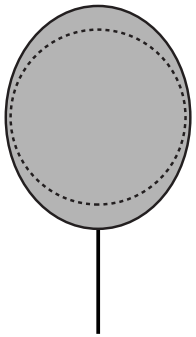
Add fiducial, dissolve adhesive

Transferring the capsule requires precision fixturing

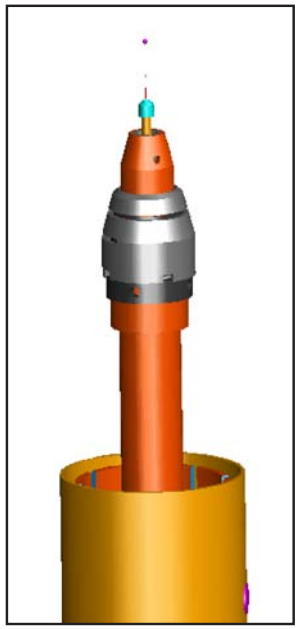


E20186a

Machined capsules are coated, characterized for gas retention, and fielded from a planar moving cryostat



Capsule sent from General Atomics, then Al sputter coated for gas retention



Room-temperature moving cryostat with a spherical target (positioning accuracy <10 μm, 1-h shot cycle)

Advantages:

- Orientation
- Symmetry

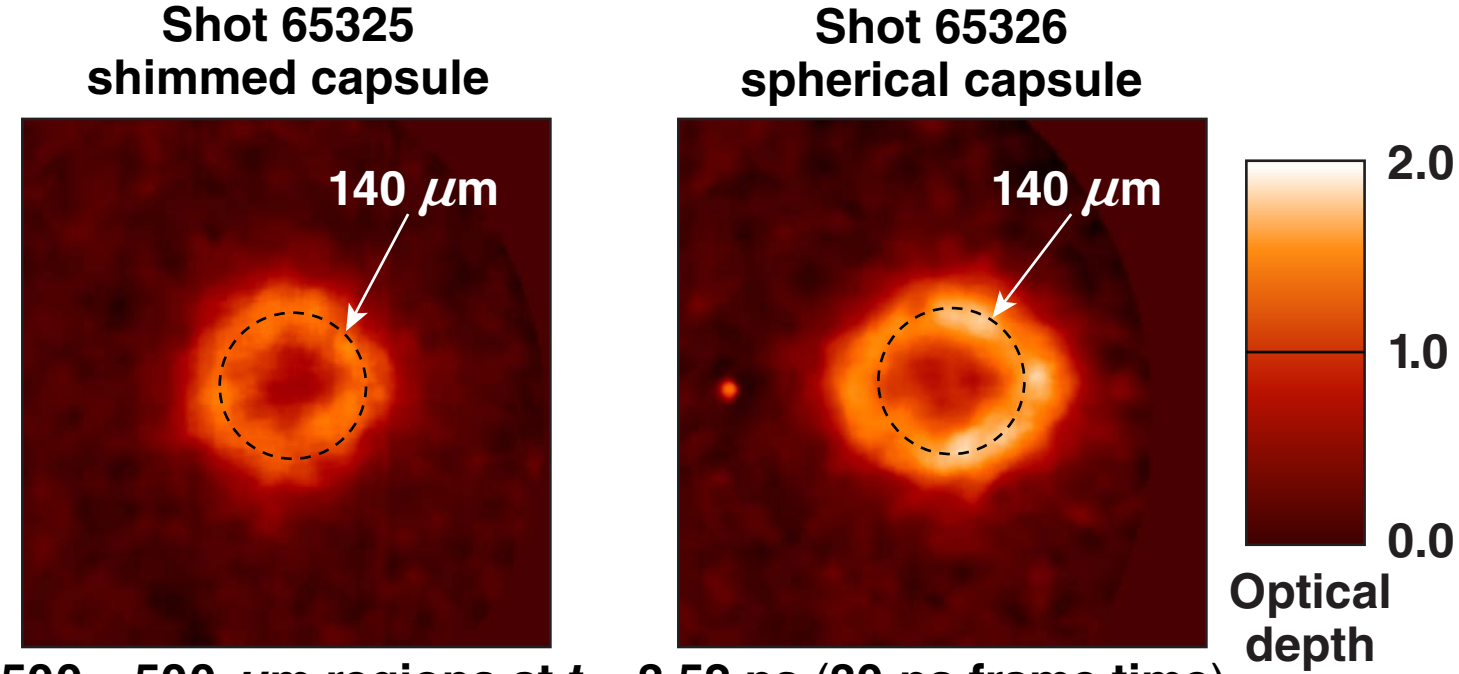
Challenges: machining and accounting for orientation and gas retention

Results

Framed radiographs of polar-driven target implosions on OMEGA show improved implosion symmetry with target shimming

UR LLE

10 atm, D_2-filled, 27-μm-thick CH capsules, imploded with triple-picket pulses from 40 OMEGA beams, 14 kJ on target, backlit with Ti x-ray emission at 4.7 keV



500 × 500-μm regions at t = 3.52 ns (30-ps frame time)

The shimmed capsule implodes more uniformly with this beam pointing (120-, 140-μm offsets for Rings 2 and 3).

E21186

Summary/Conclusions

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  - 60-beam OMEGA laser implodes a cryogenic capsule with 100-μm-thick DT ice

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    Issue: wall-thickness variation and mounting strategy